International Journal of Home Economics, Hospitality and Allied Research, 1(1): 46-59.
DOI: 10.5281/zenodo.6946361
Received: April 21, 2022
Revised: July 09, 2022
Accepted: July 30, 2022
Published: July 31, 2022

Original Research Report

Production and Quality Evaluation of Acha-Based Bread

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Abstract: Bread is a basic staple food consumed by most people all over the world right from the ancient time. This study investigated the functional, chemical, physical and sensory properties of acha based bread. The bread sweetened with date fruit powder was produced from different blends (10:90, 20:80, 30:70, 40:60, 50:50 and 60:40) of wheat and acha flour respectively. Bread produced with 100% wheat flour served as the control. Functional properties of the flour blends and physicochemical and sensory properties of the bread were evaluated using standard laboratory procedures. The functional properties of the flour blends showed significance differences ($p<0.05$) in all the parameters determined. The proximate composition revealed that increased substitution with acha flour resulted to significant increase in the crude fiber, ash, carbohydrate and energy of the bread samples. There were significant differences ($p<0.05$) in the physical properties of the bread samples. The sensory properties revealed that the bread samples varied in appearance, taste, texture and aroma with the control having the highest rating for general acceptability followed by bread produced from blends of 40 and 50 % acha flour. This study therefore, deduced that acceptable bread can be produced with up to 40% substitution of acha flour.
Keywords: Acha, Bread, Date Fruit Powder, Sensory Properties, Wheat

1. Introduction

Bread is an important part of the human diet providing energy, protein, dietary fibre, vitamins and minerals (Villarino et al., 2014). Bread is basically produced by baking of dough which is obtained from mixture of flour, salt, sugar, yeast, and water (Adebayo-Oyetoro et al., 2016). Sugar, one of the major ingredients for bread production, contains high calories with no essential nutrients, thus, causing metabolic problems like type II diabetes and obesity (Peter et al., 2017). Substitution of sugar with date fruit pulp in bakery products has been advocated for as a means of curbing the afore-stated health related issues (Peter et al., 2017).

Acha (*Digitaria exilis*) has the potential to significantly play an important role in food security in developing countries like Nigeria (Ayo et al., 2018). It is a rich source of vitamins, minerals, fibre, carbohydrate, protein, amino acids containing methionine and cysteine (Istifanus & Agbo, 2016). Acha has more protein and fiber contents than rice, and greater carbohydrate content than millet, sorghum and maize. The tiny grains are gluten-free and when cooked is light and easy to digest and can be included in many recipes (Chinwe et al., 2015), but acha is underutilized despite its overwhelming nutritional advantages (Ayo et al., 2018).

Wheat (*Triticum aestivum*) has been the major raw material used in the manufacture of bread for a long time. The common use of wheat in bakery is due to its gluten forming proteins, gliadins and glutenins (Barak et al., 2013) which when mixed with water form a matrix providing the dough structure needed for the development of desirable high volume and soft texture of bread (Villarino et al., 2014). In many countries, particularly in sub-Saharan Africa, supply of wheat basically used in bread production is inadequate to meet the bread eating habit of consumers, which is increasing with an increase in urbanization (Nwanekezi & Umeonuorah, 2013). One method to alleviate the shortage of wheat flour is to use composite flours prepared from other cereal grain (Nwanekezi & Umeonuorah, 2013).

Date fruit (Phoenix dactylifera) is one of the oldest cultivated trees and its fruit has been a dietary staple around the world for many centuries (Tang et al., 2013). Date fruit provides the perfect natural alternative to sugar like glucose, fructose and sucrose that furnishes the body with instant energy (Sultana et al., 2015). Aside this, complete replacement of sugar with date fruit in bakery products like bread will save substantial fraction of foreign exchange spent on importation of sugar (Nwanekezi et al., 2015). Regular intake of the wheat-acha bread sweetened with date fruit is an excellent approach to improve human health. This will increase the use of date fruit in bakery products and protect consumers of bread from being victims of metabolic problems such as type II diabetes and obesity. The goal of this research is to produce acceptable and health benefit bread from wheat/acha composite.

1.1. Statement of Problem

Wheat is the basic raw material for bread making due to the presence of gluten in it. However, in many countries especially in sub-Saharan Africa including Nigeria, its supply is inadequate due to high cost of importation. Acha (also called the grain of life), a food security crop with high potential has been so underutilized that it is regarded as the lost crop of Africa, having received very little attention as compared to sorghum, pearl millet, and maize (Chinwe *et al*., 2015).

1.2. Purpose of the Study

The main objective of this work was to produce bread from flours of wheat and acha .

Specific Objectives are to:

(a) Produce flour blends from wheat and acha and determine their functional properties.
(b) Produce bread with the flour blends of wheat and acha, determine proximate composition, physical and sensory properties of the bread.

1.3. Research Questions

(a) What are the functional properties of flour blends of wheat and acha?
(b) What is the proximate composition of bread produced from flour blends of wheat and acha?
(c) What are the physical properties of bread produced from flour blends of wheat and acha?
(d) What are the sensory/general acceptability of bread produced from flour blends of wheat and acha?

2. Materials and Methods

1.1. Design for the Study

A completely randomized design was used in this study.

1.1.1. Ethics Approval of Research

The study was carried out with informed consent, anonymity, and confidentiality of the respondents who voluntarily participated in the organoleptic properties of the study. The procedures for the organoleptic studies were strictly followed. There was strict compliance with the ethical demands of sensory evaluation as required in research studies.

2.2. Area of the Study

This study was conducted in the Food Processing laboratory of the Department of Food Science and Technology, Michael Okpara University of Agriculture Umudike and Central Laboratory of National Root Crop Research Institute (NRCRI) Umudike, all in Abia State of Nigeria.

2.3. Materials Procurement

Wheat grains, acha grains and date fruits were procured from Ubani Main Market in Umuahia North Local Government Area, Abia State. Reagents that were used for this study were obtained from the Biochemistry Laboratory, National Root Crops Research Institute, Umudike, Abia State, Nigeria.

2.4. Sample Preparations

2.4.1 .Production of wheat flour: In the production of wheat flour, wheat grains were sorted, washed (in clean water) and drained of water using a perforated plastic bowl. The clean wheat grains were oven dried (Gallenkemp, 300 Plus, England) at 60ºC for 8 h, milled using hammer mill (HMC-HM6630, China) and sieved (0.2 mm mesh size) to obtain wheat flour that was packaged in a polyethylene bag until needed.

2.4.2. Production of acha flour: Acha flour was produced as described by Mbaeyi-Nwaoha and Uchendu (2016). Acha grains were sorted, washed (in clean water) and drained of water with a perforated plastic bowl. The clean acha grains were oven dried (Gallenkemp, 300 Plus, England) at 50ºC for 6 h, milled using hammer mill (HMC-HM6630, China) and sieved (0.2 mm mesh size) to obtain acha flour which was packaged in a polyethylene bag until needed.

2.4.3. Production of date fruit pulp flour: The method described by Peter et al. (2017) was used in production of date fruit pulp flour. Date fruits were sorted, manually de-seeded, washed in water, drained (off water) and oven dried at 75ºC for 6 h (Gallenkemp, 300 Plus, England). The dried date fruit pulp were milled using hammer mill (HMC-HM6630, China) and sieved (through 0.35 mm mesh size) to obtain date fruit pulp flour which was packaged in a transparent polyethylene bag until needed.

2.4.4. Formulation of Composite Flour: Wheat flour was blended with acha flour at the ratios of 100:0(control), 10:90, 20:80, 30:70, 40:60, 50:50 and 60:40. Sample made with 100 % wheat flour (100:0) served as the control.

2.4.5. Production of Bread: The method described by Olubunmi et al. (2015) was adopted and used in the production of the bread. The recipe for the bread production are as follows: composite flour (1000g), margarine (50g), date pulp flour (40 g), milk flavour (10 g), egg (325 ml), yeast (30 g), salt (15 g) and water (600 ml). The straight dough method was used in

the bread production. Composite flour was mixed with ingredients and manually kneaded. Thereafter, the dough was scaled and molded, panned, proved (for 3 h) and baked (at 220 ºC for 25 min) to obtain bread. The bread produced was cooled and packaged in an airtight low density transparent polyethylene bag.

2.5. Sample Analysis Technique

2.5.1. Determination of Functional Properties of Flour: The methods described by Onwuka (2018) was used in determining the following; wettability, bulk density, water absorption capacity, oil absorption capacity, gelation temperature, swelling index, foam capacity and foam stability of the bread samples.

2.5.2. Determination of Proximate Composition: Proximate composition (moisture, protein, fat, fibre, ash) of the bread samples were determined in triplicates except for carbohydrate content which was determined by difference and caloric value which was determined by Atwater factor (AOAC, 1990).

2.5.3. Physical Properties of Bread: The method adopted by Dabels et al. (2016) was used to determine bread weight, width, specific volume and oven spring. Bread volume was determined as described by Eke-Ejiofor et al. (2015) and bread density was determined by Akubor and Ishiwu (2013) method.

2.5.4. Sensory Properties of the Bread Produced from Wheat – Acha Composite Flours: The sensory properties of the bread were ascertained according to the method described by Iwe (2014). A total of 25 semi trained panelists performed the sensory test to determine the appearance, taste, aroma, texture, and general acceptability of the bread on 9-point Hedonic scale (1 = dislike extremely and 9 = like extremely).

2.6. Data Analysis Technique

Results of all determinations were expressed as means of duplicate values. Data were subjected to One-way Analysis of Variance (ANOVA) and significant differences detected using Duncan multiple range test at 95% confidence level (p<0.05). An IBM SPSS Statistical package (version 22.0) was used for all statistical analyses.

3. Results and Discussion

3.1. Functional Properties of Flour Blends of Wheat and Acha

Table 1: Functional Properties of Flour Blends of Wheat and Acha

SAMPLE Wheat: *Acha*	Bulk density (g/cm^3)	Water absorption capacity (g/ml)	Oil absorption capacity (g/ml)	Foam Capacity (%)	Foam stability (%)	Swelling index (g/ml)	Wettability (Sec)	Gelatinization Temperature (°C)
100:0	$0.78^{cd}\pm0.01$	$2.02^{a}\pm0.01$	$1.48^{f}\pm0.02$	$12.82^{a}\pm0.03$	$4.76^{a}\pm0.02$	$5.30^{b}\pm0.03$	$0.92^{bc}\pm0.02$	$60.14^{f}\pm0.02$
10:90	$0.86^{a}\pm0.02$	$1.85^{d}\pm0.01$	$1.98^{a}\pm0.02$	$7.35^{g}\pm0.01$	$2.82^{f}\pm0.01$	$5.96^{a}\pm0.02$	$0.97^{a}\pm0.01$	$70.24^{a}\pm0.01$
20:80	$0.84^{ab}\pm0.02$	$1.87^{d}\pm0.01$	$1.86^{b}\pm0.01$	$7.99^{f}\pm0.01$	$2.93^{e}\pm0.02$	$4.91^{d}\pm0.01$	$0.96^{ab}\pm0.02$	$68.19^{a}\pm0.01$
30:70	$0.82^{bc}\pm0.02$	$1.92^{c}\pm0.02$	$1.71^{c}\pm0.03$	$9.27^{e}\pm0.02$	$3.38^{d}\pm0.03$	$4.55^{e}\pm0.02$	$0.95^{abc}\pm0.02$	$66.98^{b}\pm0.04$
40:60	$0.78^{d}\pm0.01$	$1.96^{b}\pm0.01$	$1.61^{d}\pm0.01$	$9.82^{d}\pm0.03$	$3.88^{c}\pm0.04$	$3.52^{f}\pm0.04$	$0.95^{abc}\pm0.01$	$65.43^{c}\pm0.04$
50:50	$0.75^{de}\pm0.01$	$1.99^{ab}\pm0.01$	$1.69^{c}\pm0.02$	$10.32^{c}\pm0.04$	$4.19^{b}\pm0.01$	$5.25^{c}\pm0.04$	$0.93^{abc}\pm0.01$	$63.12^{d}\pm0.03$
60:40	$0.72^{e}\pm0.01$	$2.02^{a}\pm0.03$	$1.53^{e}\pm0.03$	$10.83^{b}\pm0.03$	$4.74^{a}\pm0.03$	$2.97^{g}\pm0.02$	$0.91^{c}\pm0.01$	$63.02^{e}\pm0.74$

Values are means $\pm$ standard deviation of duplicate determination. Mean values in the same column with different superscript are significantly different (p<0.05).

Functional properties of the flour blends of wheat and acha are presented in Table 1. The bulk density of the flour blends ranged from 0.72(wheat:acha (60:40) to 0.86 g/ml (wheat:acha (10:90). There were significance differences (p<0.05) among the bulk density of the flours. The water absorption capacity of the flour blends significantly (p<0.05) increased from 1.85 to 2.02 g/ml for wheat:acha (10:90) and wheat:acha (100:0 and 60:40) respectively. The oil absorption capacity of the flour blends increased significantly (p<0.05) from 1.48 to 1.98g/ml for the control (100% wheat) and wheat:acha (10:90) respectively. The result of the foam stability showed that flour produced from the control sample (100% wheat) had the

highest value (4.76%), and was not significantly different (p>0.05) from flour blends of wheat:acha(60:40) while the least value (2.82%) was obtained in flour produced from wheat:acha (10:90). The swelling index of the flour blends significantly (p<0.05) increased from 2.97 to 5.96 g/ml for wheat:acha (60:40) and wheat:acha (10:90) respectively. The wettability of the flour blends ranged from 0.92 - 0.97 sec for wheat:acha (10:90) and wheat:acha (60:40) respectively. The gelatinization temperature of the flour blends significantly (p<0.05) increased from 60.14(control-100% wheat) to 70.24°C(wheat: acha (10:90).

3.2. Proximate Composition of Bread produced from Flour Blends of Wheat and Acha

Table 2: Proximate Composition of Bread produced from Flour Blends of Wheat and Acha

SAMPLES Wheat: Acha	Moisture content (%)	Crude protein (%)	Crude fibre (%)	Fat content (%)	Ash content (%)	Carbohydrate content (%)	Energy value (Kcal/100g)
100:0	$23.42^{a}\pm0.03$	$13.16^{a}\pm0.01$	$0.76^{b}\pm0.03$	$10.99^{f}\pm0.01$	$1.38^{d}\pm0.03$	$50.30^{g}\pm0.02$	$353.19^{g}\pm0.63$
10:90	$10.84^{g}\pm0.03$	$8.83^{g}\pm0.02$	$0.87^{a}\pm0.03$	$13.54^{a}\pm0.02$	$1.83^{a}\pm0.03$	$64.10^{a}\pm0.08$	$413.52^{a}\pm0.23$
20:80	$12.26^{f}\pm0.04$	$9.31^{f}\pm0.01$	$0.82^{a}\pm0.03$	$13.26^{b}\pm0.02$	$1.78^{a}\pm0.03$	$62.58^{b}\pm0.04$	$406.86^{b}\pm0.04$
30:70	$13.61^{e}\pm0.02$	$9.85^{e}\pm0.02$	$0.74^{bc}\pm0.01$	$13.55^{a}\pm0.01$	$1.71^{b}\pm0.01$	$60.50^{c}\pm0.01$	$403.45^{c}\pm0.18$
40:60	$15.05^{d}\pm0.03$	$10.26^{d}\pm0.04$	$0.70^{cd}\pm0.03$	$12.69^{c}\pm0.01$	$1.68^{b}\pm0.01$	$59.62^{d}\pm0.01$	$393.73^{d}\pm0.01$
50:50	$16.46^{c}\pm0.04$	$10.76^{c}\pm0.01$	$0.66^{de}\pm0.02$	$12.46^{d}\pm0.02$	$1.62^{c}\pm0.02$	$58.06^{e}\pm0.04$	$387.38^{e}\pm0.04$
60:40	$19.86^{b}\pm0.04$	$11.23^{b}\pm0.02$	$0.62^{e}\pm0.02$	$12.12^{e}\pm0.01$	$1.57^{c}\pm0.02$	$54.62^{f}\pm0.01$	$372.46^{f}\pm0.99$

Values are means + standard deviation of duplicate determination. Mean values in the same column with different superscript are significantly different (p<0.05).

Table 2 shows the results of the proximate composition of bread produced from flour blends of wheat and acha. The moisture content of the bread ranged from 10.84 to 23.42 % for samples wheat:acha (20:80) and 100% wheat (control). There were significant differences (p<0.05) among the moisture content of the breads. Bread samples produced from wheat: acha (100:0) significantly (p<0.05) had the highest crude protein content (13.16 %) whereas the lowest crude protein (8.83%) was obtained in bread produced from wheat:acha (10:90). The highest value of crude fibre (0:87 %) was obtained for bread produced from wheat:acha (10:90) while the least value (0.62 %) was obtained for wheat:acha (60:40). Bread produced from wheat:acha (30:70) had the highest fat content (13:55 %), while the least value of fat (10.99 %) was recorded for the control (100% wheat). The bread samples had ash content which ranged from 1.38 to 1.83 % for control (100% wheat) and wheat:acha (10:90) respectively. The carbohydrate content of the bread samples significantly (p>0.05) increased from 50.30 to 64.10 % for the control (100% wheat) and wheat:acha (10:90) respectively. The energy value of the bread samples significantly (p<0.05) increased from 353.19 (control-100% wheat) to 413.52 Kcal/100g (wheat:acha (10:90).

3.3. Physical Properties of Bread produced from Flour Blends of Wheat and Acha

Table 3: Physical Properties of Bread produced from Flour Blends of Wheat and Acha

SAMPLES Wheat : Acha	Weight (g)	Volume (cm^3)	Specific volume (cm^3/g)	Density (g/cm^3)	Oven spring (cm)	Width (cm)
100:0	$205.20^{g}\pm0.02$	$530.62^{a}\pm0.01$	$2.62^{a}\pm0.00$	$0.38^{g}\pm0.00$	$10.93^{a}\pm0.00$	$202.42^{g}\pm0.02$
10:90	$206.74^{a}\pm0.02$	$345.71^{g}\pm0.01$	$1.12^{g}\pm0.01$	$0.90^{a}\pm0.00$	$6.57^{g}\pm0.03$	$310.04^{a}\pm0.02$
20:80	$206.46^{b}\pm0.03$	$360.25^{f}\pm0.03$	$1.22^{f}\pm0.00$	$0.82^{b}\pm0.00$	$6.70^{f}\pm0.00$	$295.14^{b}\pm0.03$
30:70	$206.23^{c}\pm0.04$	$375.45^{e}\pm0.02$	$1.34^{e}\pm0.00$	$0.75^{c}\pm0.00$	$6.83^{e}\pm0.02$	$280.38^{c}\pm0.04$
40:60	$205.89^{d}\pm0.03$	$390.57^{d}\pm0.04$	$1.48^{d}\pm0.00$	$0.68^{d}\pm0.00$	$6.98^{d}\pm0.03$	$264.57^{d}\pm0.03$
50:50	$205.76^{e}\pm0.03$	$400.83^{c}\pm0.03$	$1.71^{c}\pm0.01$	$0.59^{e}\pm0.00$	$7.15^{c}\pm0.00$	$235.12^{e}\pm0.03$
60:40	$205.62^{f}\pm0.01$	$420.05^{b}\pm0.01$	$1.98^{b}\pm0.01$	$0.51^{f}\pm0.00$	$7.29^{b}\pm0.02$	$212.67^{f}\pm0.01$

Values are means $\pm$ standard deviation of duplicate determination. Mean values in the same column with different superscript are significantly different ($p<0.05$)

Table 3 shows the physical properties of bread produced from flour blends of wheat and acha. The weight of the bread samples ranged from 205.20(control-100% wheat) to 207.75g (wheat:acha (10:90). The volume of the bread samples significantly ($p<0.05$) increased from 345.71(wheat:acha (10:90) to 530.62 cm^3(control-100:% wheat). The specific volume of the bread samples ranged from 1.22 - 2.62 cm^3/g for wheat:acha (10:90) and wheat:acha (100:0) respectively. Bread samples produced from wheat:acha (10:90) significantly ($p<0.05$) had the highest (0.90 g/cm^3) value of density whereas the lowest (0.38 g/cm^3) value was obtained for wheat:acha (100:0). Bread samples produced from the control (100% wheat) recorded the highest (10.93cm) value of oven spring while the lowest (6.57cm) value was obtained in bread produced from wheat:acha (10:90). The result of the width of the bread samples shows significant ($p<0.05$) increase from 202.42 cm(control (100% wheat) to (310.04 cm) (wheat:acha (10:90).

3.4. Sensory Properties of Bread produced from Flour Blends of Wheat and Acha

Table 4: Sensory Properties of Bread produced from Flour Blends of Wheat and Acha

Samples Wheat:Acha	Appearance	Taste	Texture	Aroma	General Acceptability
100:0	$8.00^{a}\pm0.87$	$7.00^{a}\pm1.35$	$7.28^{a}\pm1.43$	$6.88^{a}\pm1.33$	$7.48^{a}\pm1.09$
10:90	$5.64^{c}\pm1.73$	$4.72^{c}\pm1.46$	$5.04^{b}\pm1.72$	$5.04^{b}\pm1.81$	$5.36^{c}\pm1.75$
20:80	$5.60^{c}\pm1.71$	$4.96^{bc}\pm1.24$	$5.40^{b}\pm1.53$	$5.24^{b}\pm1.90$	$5.76^{bc}\pm1.54$
30:70	$6.12^{bc}\pm2.11$	$4.80^{c}\pm1.83$	$5.36^{b}\pm1.68$	$5.08^{b}\pm1.89$	$5.48^{c}\pm1.96$
40:60	$6.24^{bc}\pm1.54$	$5.60^{bc}\pm1.68$	$5.48^{b}\pm1.66$	$5.56^{b}\pm1.90$	$5.96^{bc}\pm1.27$
50:50	$6.84^{b}\pm1.82$	$5.88^{b}\pm1.81$	$6.08^{b}\pm1.87$	$5.52^{b}\pm1.78$	$6.20^{bc}\pm1.56$
60:40	$6.84^{b}\pm1.93$	$5.88^{b}\pm2.09$	$5.84^{b}\pm1.95$	$5.52^{b}\pm2.42$	$6.56^{b}\pm2.04$

Values are means $\pm$ standard deviation of duplicate determination. Mean values in the same column with different superscript are significantly different ($p<0.05$)

The sensory properties of the bread produced from flour blends of wheat and acha are presented in Table 4. The mean scores for appearance of the bread ranged from 5.60(wheat:acha (10:90) to 8.00(control-100% wheat). Bread samples showed that wheat:acha (10:90) had the lowest mean score (4.72) for taste while the control (100% wheat) had the highest (7.00). There were significant differences (p<0.05) among the mean scores for taste of the bread samples. The texture was significantly (p<0.05) highest (7.28) in bread produced from the control (100% wheat) and lowest (5.04) in bread produced from wheat:acha (10:90). The mean score for aroma was highest (6.88) in the control (100% wheat) and lowest mean score(5.04) and lowest for wheat:acha (10:90). In terms of general acceptability the control (100:% wheat) was significantly (p>0.05) preferred amongst the bread samples followed by bread produced from wheat:acha (40:60) and (50:50).

Lower bulk density in the flour blends as seen in wheat:acha (60:40) (Table 1) is an indication that the flour will be more suitable in food formulation especially food with less retrogradation (Oladele and Aina, 2009). The range of bulk density obtained in this study was higher than 0.586 – 0.693 g/ml obtained for wheat – pigeon pea blends (Arukwe, 2021). Bulk density is important in determining the packaging requirement, material handling and application in food industry (Falade and Okafor, 2015). Water absorption capacity refers to the amount of water retained by a food product after filtration and application of mild pressure of centrifugation (Falade and Okafor, 2015). The samples wheat:acha (100:0) and (60:40) with the highest water absorption capacity obtained in this study indicates that they will be useful in the formulation of foods such as sausage, dough, produced cheese and bakery products (Chandra et al., 2015). Oil absorption capacity refers to protein's ability to bind fat. It is an important factor because fat acts as flavour retainer and improves the mouth feel of foods (Otegbayo et al., 2013). The lower oil absorption capacity of flour produced from wheat:acha (100:0) may be attributed to its higher protein content than other flour samples. The range of oil absorption capacity obtained in this study was higher(1.48-1.98 g/ml) than 0.18 to 0.80 g/ml reported for acha, wheat, cashew kernel and prawn composite flour (Emelike et al., 2020). High foam stability is a desirable attribute for flours intended for the production of variety of baked goods such as cookies, muffins, etc. It also acts as functional agent in other food formulations (Chukwu & Abdul-Kadir, 2008). The range of foam stability obtained in this study was within the range (1.94 to 13.40%) reported for rice, green gram, potato and wheat composite flour (Chandra et al., 2015). Swelling index is an indication of the cumulative effects of starch quality, specifically amylose/amylopectin ratio as reflected by the volume of gel produced when flour is heated with an excess of water (Buckman et al., 2018). The highest value of swelling index recorded for wheat:acha (10:90) indicates that the flour possess higher starch content than other flour samples (Kusumayanti et al., 2015), and can be used for the formulation of variable products. The highest value of wettability obtained in flour produced from wheat:acha (10:90) could probably be due to high crude fiber contents of acha flour as compared to the control(100% wheat). This suggests that the flour sample(wheat:acha (10:90) will disperse more slower in water than other flour samples. The ability of food flours or powder to disperse is largely dependent on their wettability capacity (Offia-Olua et al., 2019). Gelatinization temperature is influenced by the amount of loose starch granules available in the sample (Ubwa et al., 2012). It could be explained that flour produced from the control (100% wheat) has higher loose starch granules compared to other flour samples. The least gelatinization temperature obtained in flour produced from the control (100% wheat) implies that it will require lesser heat energy and costs. The highest value of moisture obtained in bread processed from wheat:acha (100:0) could either be that wheat flour used in this study possessed higher moisture

content than acha flour. Igbabul et al. (2019) reported similar findings where bread produced with 100% wheat flour had the highest moisture content (28.44%) compared to 22.11 to 26.56 % reported for wheat bread substituted with water yam and brown hamburger bean flours. Moisture content is basically used as a measure of stability and susceptibility to microbial contamination (Uyoh et al., 2013). However, bread samples with moisture content below or within the range of 15% (Table 2) is said to have better shelf stability. Protein is needed as building blocks for the body, necessary for growth and for repair of damaged tissues (Onwuka, 2018). The range of crude protein obtained in this study was lower than 12.40 to 17.48 % reported for bread produced from wheat, acha and mung bean composite flour (Dabels et al., 2016). Crude fibre is the indigestible component of plant material which includes cellulose, hemicelluloses, pectin, lignins, and other plant materials. The highest crude fibre obtained in bread processed from wheat:acha (10:90) suggests that acha flour possesses higher crude fibre than wheat flour. This is in agreement with the report that the nutrient constituents of a food material reflect in its end product (Davidson et al., 2017).

Bread samples with high crude fibre indicate that they will be beneficial for digestive health (Arukwe et al., 2021). The fat content of the bread produced from all the flour blends were higher than the control. Increase in fat was observed as the level of acha flour increases. A previous study reported a lower fat content in bread made from 100% wheat flour (2.62 %) compared to 2.87 to 5.60 % obtained in bread substituted with bambara nut and yellow root cassava flour (Okoye & Ezeugwu, 2019). Fat plays a significant role in the shelf life of food products and as such, relatively high fat content could be undesirable in baked products because fat can promote rancidity in food. It was observed that the higher the proportions of acha flour in the bread, the higher the ash content. This suggests that acha flour possesses higher ash than wheat flour. Ash content of a food material is an indication of its mineral constituents, therefore, bread samples with high fat will provide vital and beneficial minerals needed for development of human bones and body metabolism (Onwuka, 2018). The highest value of carbohydrate obtained in bread from wheat:acha (10:90) suggests that it will contribute more in maintenance of the plasma glucose level, sparing the body protein from being easily digested (Onimawo et al., 2019). Energy is an essential property of food. The energy human body requires for every activity is supplied by food. The highest energy value obtained in bread produced from wheat:acha (10:90) could be attributed to its high carbohydrate content compared to other bread samples. This is in line with the report by Khan et al. (2013) that carbohydrates are principal and indispensable sources of energy.

Bread weight is determined by amount of baked dough, moisture and carbon dioxide diffused out of the loaf during baking (Yusufu and Ejeh, 2018). The highest value of weight obtained in bread made from wheat:acha (10:90) could be attributed to less retention of carbon dioxide gas in the blended dough, resulting in heavy dough and thus heavy loaves (Menon et al., 2015). Loaf volume can be considered as the most important bread characteristic since it provides a quantitative measurement of baking performance (Ibrahim et al., 2020). The least value for volume obtained in bread produced from wheat:acha (10:90) could probably be due to the reduction of gluten which is responsible for the viscoelastic property of bread volume (Makinde, 2014). Ibrahim et al. (2020) also affirmed that the use of weak flour or one low in enzyme activity results to decrease in loaf volume. Specific volume is affected by quantity and quality of protein in the flour as well as proofing time (Peluola-Adeyemi et al., 2021). The highest value of specific volume obtained in bread produced from the control sample (100% wheat) could be attributed to the fact that it possesses substantial gluten content unlike the other samples. This result is in agreement with the findings of Igbabul et al.

(2019), who reported a decrease in bread specific volume, from 2.83 cm^3/g to 2.38 cm^3/g, due to inclusion of water-yam and brown hamburger bean flour to the wheat flour. It was observed that increased substitution with acha flour resulted to significant increase in density of the bread samples. This could probably be that *acha* flour brought about weaker and less elastic dough and a reduction in the leavening ability, resulting in bread with higher density (Eriksson et al., 2014). Oven spring is the rapid expansion of dough in the first few minutes in the oven (Peluola-Adeyemi et al., 2021). The highest value of oven spring obtained in bread produced from wheat:acha (100:0) could be attributed to the positive contribution of wheat flour, which its gluten prompted increased loaf oven spring. This is corroborate with the report by Peluola-Adeyemi et al. (2021) that increase in volume of bread causes increase in internal pressure of dough thereby prompting the dough to rise rapidly in the initial stage of baking. The high value of width obtained in bread processed from wheat:acha (10:90) is of great importance considering that consumers may prefer breads with more elongated width than those with less width at the same price.

Appearance determines how fulfilling a food product is before its consumption. The least mean score of appearance obtained in bread produced from wheat:acha (10:90) could be attributed to adverse effect of acha which is not a source of gluten. Ndife et al. (2011) opined that baking properties of composite flours are impaired as well as the organoleptic attributes of their products due to dilution of gluten content. The taste of bread refers to the sweet sensation caused in the mouth by contact with the bread due to the sweetening agent, and is vital in determining its overall acceptability (Agiriga, 2014). The highest mean score of taste obtained in bread produced from the control sample (100% wheat) could be attributed to the fact that the panelists were already used to the taste of conventional bread made with 100% wheat. Texture is the quality of bread that can be decided by touch, the degree to which it is rough or smooth, hard or soft (Agiriga, 2014). The highest mean score of texture obtained in bread produced from the control sample (100% wheat) could be attributed to the positive contribution of wheat gluten. Igbabul et al. (2019) also reported higher mean score of texture in wheat bread (7.67) compared to the range of 4.33 to 6.33 reported for bread supplemented with water yam and brown hamburger bean. Aroma is a distinctive typically pleasant smell perceived by the olfactory sense. The highest mean score of aroma obtained in bread produced from wheat:acha (100:0) could be as a result of the fact that 100% wheat bread is the conventional form in which bread is consumed in Nigeria, and as such, the panelists were already used to aroma of bread made from wheat. Olaoye and Ade-Omowaye (2011) also reported higher mean score for aroma in bread produced from 100% wheat flour (6.60) than values obtained in bread samples supplemented with soybean flour (5.30 to 5.70). The highest mean score for general acceptability obtained in bread produced from 100% Wheat flour was expected since it excelled in all the sensory attributes considered. This claim corroborates with the findings of Olaoye and Ade-Omowaye (2011) that wheat bread which had the highest mean score for crust, aroma, shape, internal texture, taste and appearance also had the highest rating for general acceptability compared to bread samples supplemented with varying proportions of soybean flour. However, bread samples produced from wheat:acha (50:50) and (60:40) were also accepted by the panelist. The implication of this finding is that substitution of acha flour above 50% may result to bread that will not be generally acceptable by the consumers. It is suggested that further study should be carried out on substitution of wheat with acha flour lower than 40%.

4. Conclusion

This study has shown that nutritious and quality bread with acceptable organoleptic properties could be produced from flour blends of wheat and acha sweetened with date fruit powder. Substitution with acha flour improved the crude fibre, ash, carbohydrate and energy value. This research has established that wheat can be substituted with acha up to 40% to produce acceptable bread which possesses quality nutrients of health benefits. The bread samples would aid in solving the problem of protein energy malnutrition, mineral sources from the high ash content obtained from inclusion of acha flour and could as well serve as good diet for diabetic patients with its high crude fibre. Based on the findings, the researcher recommends that the partial substitution of wheat with 40% acha flour for bread production is feasible. Families, Hotels, Fast foods, baking industries are encouraged to substitute wheat with acha flour in bread making. The use of acha flour in bread making will not only produce bread of health benefit but create varieties in the use of acha.

Acknowledgments

The authors are grateful to the Department of Food Science and Technology, Michael Okpara University of Agriculture, Umudike, and Biochemistry Laboratory of National Root Crops Research Institute (NRCRI), Umudike, Nigeria for providing the space for the analysis. The laboratory research assistants and technologist and data analyst are also appreciated.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Stella C, Ubbor designed the study, wrote and edited the article. Vanesa C. Ezeocha proofread the article. Augusta C. Ibe-diala collected samples used for the study. Ijeoma L. Princewill-Ogbonna and Augusta C. Ibe-diala prepared the samples. All the authors participated in carrying out analysis of the samples. The authors also approved the final draft for publication.

Data availability Statement

The original contributions presented in the study are included in the article. Further inquiries can be directed to the corresponding author.

References

Adebayo-Oyetoro, A.O., Ogundipe, O. O. & Adeeko, K. N. (2016). Quality assessment and consumer acceptability of bread from wheat and fermented banana flour. *Food Science and Nutrition, 4*, 364-369. DOI: 10.1002/fsn3.298

Adejuyitan, J.A., Otunola, E. T., Akande, E. A., Bolarinwa, I. F. & Oladokun, F. M. (2009). Some physicochemical properties of flour obtained from fermentation of tiger nut (*Cyperus esculentus*) sourced from a market in Ogbomoso, Nigeria. *African Journal of Food Science, 3*, 51-55.

Agiriga, A. N. (2014). Effect of whole wheat flour on the quality of wheat-baked bread. *Global Journal of Food Science and Technology, 2*, 127-133. DOI: 10.1.1.682.4557

Akubor, P. I. & Ishiwu, C. (2013). Chemical composition, physical and sensory properties of cakes supplemented with plantain peel flour. *International Journal of Agricultural Policy and Research*, *1*, 087-092.

AOAC (1990). *Official Method of Analysis*. Association of Analytical Chemists, Washington DC.

Arukwe, D. C. (2021). Proximate composition, functional and pasting properties of wheat flour supplemented with combined processed pigeon pea flour. *International Journal of Food Science and Nutrition, 6*, 59-64.

Arukwe, D. C., Ezeocha, V. C. & Ubbor, S. C. (2021). Production and evaluation of cookies from composites of sprouted wheat, sorghum and African yam bean seed flours. *Nigerian Agricultural Journal*, *52*, 277-283.

Ayo, J.A., Ojo, M. O., Omelagu, C. A. & Najime, M. K. (2018). Proximate, phytochemical composition and sensory quality of *acha*–turmeric flour blend and biscuits. *Asian Food Science Journal, 5*, 1-16. DOI: 10.9734/AFSJ/2018/43365

Barak, S., Mudgil, D. & Khatkar, B.S. (2013). Relationship of gliadin and glutenin proteins with dough rheology, flour pasting and bread making performance of wheat varieties. *LWT-Food Science and Technology, 5*, 211–217. DOI: 10.1016/j.lwt.2012.09.011

Buckman, E. S., Oduro, I., Plahas, W. A. & Torte, C. (2018). Determination of the chemical and functional properties of yam bean *Pachyrhizuserosus* (L.) urban flour for food systems. *Food Science and Nutrition*, *6*, 457-463. DOI: 10.1002/fsn3.574

Chandra, S., Singh, S. & Kumari, D. (2015). Evaluation of functional properties of composite flours and sensorial attributes of composite flour biscuits. *Journal of Food Science and Technology, 52*, 3681–3688. DOI: 10.1007/s13197-014-1427-2

Chinwe, O. U., Ojukwu, E. O. & Jackson, B. A. (2015). *Acha*: A potential grain as a food fortifier. *Asian Journal of Agriculture and Food Sciences, 3*, 428-435.

Chukwu, O. & Abdul-kadir, A. J. (2008). Proximate chemical composition of *acha* (*Digitaria exilis* and *Digitaria iburua*) grains. *Journal of Food Technology, 6*, 214-216. DOI:jftech.2008.214.216

Dabels, N., Igbabul, B., Shar, F., Iorliam, B. & Abu, J. (2016). Physicochemical, nutritional and sensory properties of bread from wheat, acha and mung bean composite flours. *Journal of Food Science and Quality Management, 56*, 21-26.

Davidson, G. I., Ene-Obong, H. N. & Chinma, C. E. (2017). Variations in nutrients composition of most commonly consumed cassava mixed diets in South-Eastern Nigeria. *Journal of Food Quality*, *10*, Article ID 6390592. DOI: 10.1155/2017/6390592

Eke-Ejiofor, J., Deedam, J. N. & Beleya, E. A. (2015). Effect of addition of three leaf yam flour on dough properties and sensory qualities of bread. *Journal of Food Research, 4*, 133-142. DOI: 10.5539/jfr.v4n6p133

Emelike, N. J. T., Achinewhu, S. C. & Ebere, C. O. (2020). Nutritional composition, functional and organoleptic properties of breakfast cereals formulated from acha, wheat, cashew kernel and prawn. *European Journal of Agriculture and Food Sciences, 2*, 1-6. DOI: 10.24018/ejfood.2020.2.5.112

Eriksson, E., Koch, K., Tortoe, P., Akonor, T. & Oduro-Yeboah, C. (2014). Evaluation of the physical and sensory characteristics of bread produced from the varieties of cassava and wheat composite flours. *Food and Public Health*, *4*, 214-222. DOI: 10.5923/j.fph.20140405.02

Falade, K. O. & Okafor, C. A. (2015). Physical, functional and pasting properties of flours from

corms of two cocoyam (*Colocasta esculenta and Xanthosoma sagittifolium*) cultivars. *Journal of Food Science and Technology, 52*, 3440-3448. DOI: 10.1007/s13197-014-1368-9

Ibrahim, U. K., Rahman, N. A. A., Suzihaque, M. U. H., Hashib, S. A. & Aziz, R. A. A. (2020). Effect of baking conditions on the physical properties of bread incorporated with green coffee beans (GCB). *IOP Conference Series: Materials Science and Engineering*, *736*, DOI:10.1088/1757-899X/736/6/062019

Igbabul, B. D., Christy, O. E. & Ukeyima, M. T. (2019). Quality evaluation of composite bread produced from wheat, water yam and brown hamburger bean flours. *African Journal of Food Science and Technology, 10*, 42-48. DOI: 10.14303/ajfst.2019.008

Istifanus, M. F. & Agbo, E. B. (2016). Nutritional and health benefits of *acha* (*Digitaria exilis*) in the human diet – A review. *Nigerian Food Journal*, 34, 72-78.

Iwe, M. O. (2014). Current trends in sensory evaluation of foods. Revised Edition. Enugu, Nigeria: Rojoint Communication Services Ltd.

Khan, N., Ruqia, B., Hussain, J., Jamila, N., Rahman, N. & Hussain, S.T. (2013). Nutritional assessment and proximate analysis of selected vegetables from Parachinar Kurram Agency. *American Journal of Research Communication*, *8*, 184-198.

Kusumayanti, H., Handayani, N.A. & Santosa, H. (2015). Swelling power and water solubility of cassava and sweet potatoes flour. International Conference on Tropical and Coastal Region Eco-Development 2014 (ICTCRED 2014). *Procedia of Environmental Science*, *23*, 164 –167.

Makinde, A. (2014). Physical, nutritional and sensory qualities of bread samples made with wheat and black sesame (*Sesamum indicum* Linn) flours. *International Food Research Journal, 21*, 1635-1640.

Mbaeyi-Nwaoha, I. E. & Uchendu, N. O. (2016). Production and evaluation of breakfast cereals from blends of *acha* and fermented soybean paste (okara). *Journal of Food Science and Technology, 52,* 50-70. DOI: 10.1007/s13197-015-2032-8

Menon, L., Majumdar, S. D. & Ravi, U. (2015). Development and analysis of composite flour bread. *Journal of Food Science and Technology*, *52*, 4156- 4165. DOI: 10.1007/s13197-014-1466-8

Ndife, J., Abdulraheem, L. O. &_Zakari, U. M. (2011). Evaluation of the nutritional and sensory quality of functional foods produced from whole wheat and soybean flour blends. *African Journal of Food Science, 8*, 466-471.

Nwanekezi, E. C. & Umeonuorah, C. U. (2013). Quality evaluation of bread by substitution of bakery fat with bullet pear fruit oil. *IOSR Journal of Environmental Science, Toxicology and Food Technology*, *2,* 106-112.

Nwanekezi, E. C., Ekwe, C. C. & Agbugba, R. U. (2015). Effect of substitution of sucrose with date palm fruit on quality of bread. *Journal of Food Process Technology, 6*, 484. DOI: 10.4172/2157-7110.1000484

Offia-Olua, B. I., Onwuzuruike, U. A. & Okoroafor, O. S. (2019). Effect of processing on dietary fibre, proximate and functional properties of soybean (*Gyycine max mer.*) and African yam bean (*Sphenostylis stenocarpa*) flour samples. *International Journal of Agriculture and Environmental Research*, *5*, 369- 383.

Okoye, E. C. & Ezeugwu, E. H. (2019). Production, quality evaluation and acceptability of bread from wheat, bambara groundnut and yellow root cassava flours. *International Journal of Food Bioscience*, *2*, 11-17.

Oladele, A. K. & Aina, J. O. (2009). Chemical composition and properties of flour produced from

two varieties of tiger nut (*Cyperns esculentus*). A*frican Journal of Biotechnology, 6*, 2473-2476. DOI: 10.5897/AJB2007.000-2391

Olaoye, O. A. & Ade-Omowaye, B. I. O. (2011). Composite flours for breads: Potential of local crops in developing countries. In: Preedy, V. R., Watson, R. R. & Patel, V. B. (Eds.), *Flour and breads and their fortification in health and diseaseprevention* (pp. 183-192). London: Academic Press.

Olubunmi, I. P., Babatunde, K. S., Bolanle, O. O., Seyioba, S. O., Taiwo, L., Olukayode, A.O. & Nwankego, E. G. (2015). Quality evaluation of fibre-enriched bread. *International Journal of Nutrition and Food Sciences, 4*, 503-508. DOI: 10.11648/j.ijnfs.20150404.23

Onimawo, I. A., Esekheigbe, A. and Okoh, J. E. (2019). Determination of proximate and mineral composition of three traditional spices. *Acta Scientific Nutritional Health*, *3*, 111-114.

Onwuka, G. I. (2018). Food analysis and instrumentation. Theory and practices. Revised edition. Lagos, Nigeria: Naphtali Prints.

Otegbayo, B. O., Samuel, F. O. & Alalade, T. (2013). Functional properties of soy- enriched tapioca. *African Journal of Biotechnology*, *12,* 3583-3589. DOI: 10.5897/AJB12.2654

Peluola-Adeyemi, O. A., Abdus-Salaam, R. R., Obi, T. E. & Toyiemedo, N. C. (2021). Quality evaluation of bread produced from wheat flour using avocado (Persea Americana) paste as substitute. *Journal of Food Stability*, *4* 1-12. DOI: 10.36400/J.Food.Stab.4.1.2021-0041

Peter, I. A., Okafor, D. C., Kabuo, N. O., Ibeabuchi, J. C., Odimegwu, E. N., Alagbaoso, S. O., Njdeka, N. E. & Mbah, R. N. (2017). Production and evaluation of cookies from whole wheat and date palm fruit pulp as sugar substitute. *International Journal of Advancement in Engineering Technology, Management and Applied Science, 4*, 1-13.

Sultana, P., Dilruba, E., Afzal, S., Mrityunjoy, B, Subed, C., Dev, S., Md. Golam, S. J. & Md. Amirul, I., Narayan, R. and Mohammad, S. S. (2015). Nutritional analysis of date fruits (*Phoenix dactylifera L.*) in perspective of Bangladesh. *American Journal of Life Sciences*, *3*, 274-278. DOI: 10.11648.j.ajls.20150304.14

Tang, Z. X., Shi, L. E. & Aleid, S. M. (2013). Date fruit: Chemical composition, nutritional and medi cinal values, products. *Journal of the Science of Food and Agriculture, 93,* 2351–2 361.DOI: 10.1002/jsfa.6154

Ubwa, S. T., Abah, J., Asemave, K. & Shambe, T. (2012). Studies on the gelatinization temperature of some cereal starches. *International Journal of Chemistry*, *4,* 1916-9701. DOI:10.5539/ijc.v4n6p22

Uyoh, J. N., Onuegbu, N. C., Ogueke, C. C. Kabuo, N. O. & Omeire, G. C. A. (2013). Acceptability of moi-moi produced from blends of African yam bean and cowpea. *International Journal of Current Microbiology and Applied and Sciences*, *3*, 99-100.

Villarino, C. B., Jayasena, V., Coorey, R., Chakrabarti-Bell, S. & Johnson, S. (2014). The effects of bread-making process factors on Australian sweet lupin-wheat bread quality characteristics. *International Journal of Food Science and Technology, 49*, 2373-2381.DOI: 10.1111/ijfs.12595

Yusuf, M. I. & Ejeh, D. D. (2018). Production of bambara groundnut substituted whole wheat bread: functional properties and quality characteristics. *Journal of Nutrition and Food Sciences*, *8,* 731-737. DOI: 10.4172/2155-9600.1000731

Publisher: Department of Home Economics and Hospitality Management Education, University of Nigeria, Nsukka 41001, Nigeria

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